

## Estimating the Buffer Capacity of Forest Soils

James W. Hornbeck and C. Anthony Federer

The organic-matter content of New England soils is an index of buffer capacity, and can be measured to indicate how forest soils might respond to acid precipitation.

Buffer capacity, as defined herein, is the milliequivalents of  $H^+$  or  $OH^-$  that must be added to a kilogram of soil to change its pH by one unit ( $meq\ kg_s^{-1}\ pH^{-1}$ ). As such, it is an index of how soil pH will respond to  $H^+$  in acid precipitation. At four locations in New England, we measured buffer capacity of organic and mineral horizons for well-drained forest soils under second-growth forests and in new and regrowing clearcuts. The sites included a spruce-fir forest in central Maine, two northern hardwood forests in northern New Hampshire, and a central hardwood forest in southern Connecticut. Soil materials were titrated by adding known amounts of HCl or NaOH and measuring the pH after 24 hours. Details on methods are given in Federer and Hornbeck (1985).

### Figuring Organic Content

Buffer capacity was closely related to organic-matter content in all tested soils (fig. 1). Virtually the same relation holds regardless of location and regardless of whether the soil was well drained or poorly drained, cutover, or uncut. The results can be generalized by the expression:

$$(meq\ kg_s^{-1}\ pH^{-1}) = 100 \times (kg_o\ kg_s^{-1})$$

James W. Hornbeck and C. Anthony Federer are with the Northeastern Forest Experiment Station, USDA Forest Service, Durham, NH.

when organic fraction exceeds  $0.10\ kg_o\ kg_s^{-1}$ , and

$$(meq\ kg_s^{-1}\ pH^{-1}) = 3 + 70 \times (kg_o\ kg_s^{-1})$$

when organic fraction is less than  $0.10\ kg_o\ kg_s^{-1}$ . Subscript *o* stands for organic matter and *s* stands for oven-dry soil.

### Implications for Forest Managers

The buffer capacity of organic matter

can indicate the susceptibility of coarse-textured forest soils to acid precipitation. Organic fractions of soils (needed for the equations) can be determined by placing weighed, oven-dried samples from important horizons, including the forest floor, in a muffle furnace for four hours at  $550^\circ\ C$ . The loss in mass from burning divided by the initial oven-dry mass is the organic fraction, expressed as  $kg_o\ kg_s^{-1}$ . This value can be placed in the equations above or compared with figure 1 to obtain an estimate of buffer capacity for each horizon. The higher the buffer capacity, the greater the ability to resist change due to acid precipitation.

The importance of organic versus mineral horizons in buffering acid precipitation is best shown on a unit-area

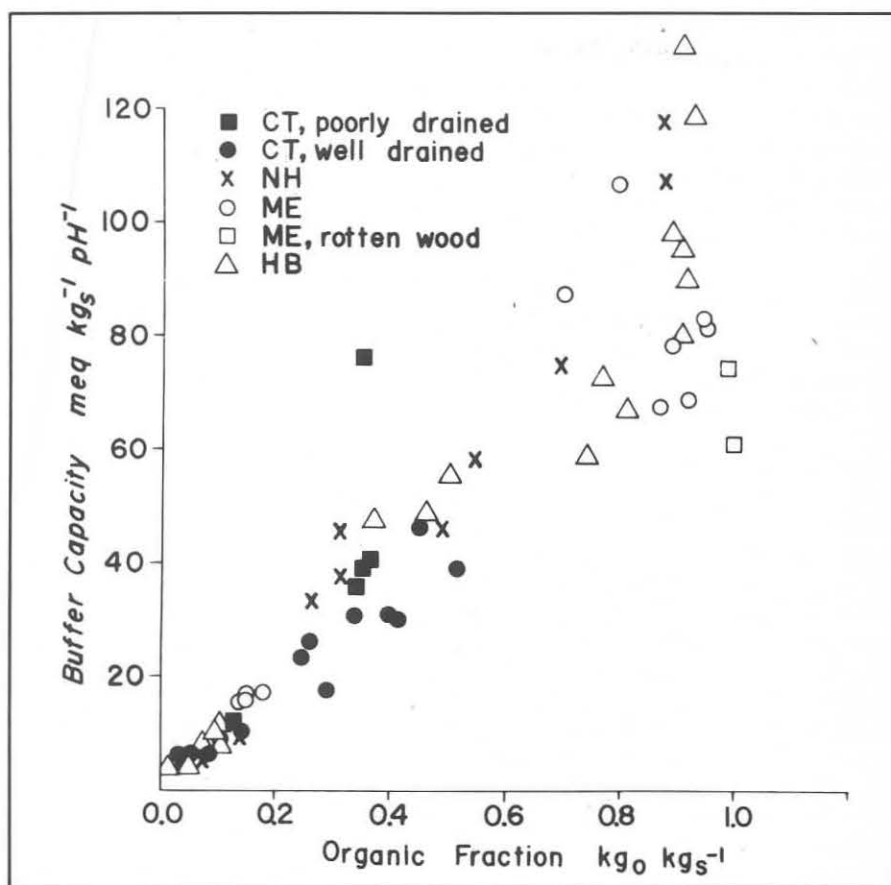


Figure 1. Relationship between organic fraction and soil buffer capacity. HB and NH represent two locations in New Hampshire. Clearcut and uncut sites are combined.

basis. Such an evaluation requires data on thickness, bulk density, and stone content of each horizon.

Where the bulk density has not been measured, the following logarithmic relationship can be used:

$$\ln BD = -2.314 - 1.0788 \ln OF - 0.1132 (\ln OF)^2$$

where *BD* is the bulk density in  $\text{kg}_s \text{L}_s^{-1}$  and *OF* is the organic fraction in  $\text{kg}_o \text{kg}_s^{-1}$  (Federer 1983). This relation can be used for both organic and mineral horizons so long as the organic fraction exceeds  $0.02 \text{ kg}_o \text{kg}_s^{-1}$ . At lower organic fractions a bulk density of  $1.4 \text{ kg}_s \text{L}_s^{-1}$  can be used. The buffer capacity for each horizon in  $\text{keq ha}^{-1} \text{pH}^{-1}$  is then calculated as (thickness, cm)  $\times$  (bulk density,  $\text{kg}_s \text{L}_s^{-1} \times (1 - \text{stone fraction}) \times (\text{buffer capacity, meq kg}_s^{-1} \text{pH}^{-1}) \times (0.1 \text{ keq L}_s \text{meq}^{-1} \text{ha}^{-1} \text{cm}^{-1})$ .

Table 1, showing calculations for the study site in Maine, can be used to assess buffer potential with increasing acidification. The annual input of hydrogen ion in the Northeast averages about  $1 \text{ keq H ha}^{-1} \text{pH}^{-1}$ , that is, 1,000 mm of precipitation at pH 4.0. Under the worst-case assumption of no neutralizing factors, adding all the hydrogen in precipitation to the organic horizons (*O<sub>e</sub>* and *O<sub>a</sub>*) in table 1 would produce a pH decline of 1 unit in about 14 years. Spreading the hydrogen through the whole soil mass would require 31 years for a change of 1 pH unit.

These values must be considered only as indexes of potential changes, since processes such as weathering, denitrification, and storage of nutrients in biomass can mitigate effects of acid precipitation. The values do provide a basis for comparing soils and soil horizons. Because of its mass, organic matter in mineral horizons may buffer significant additions of hydrogen ions—contrary to prevailing ideas that most buffer capacity is located in the organic horizons of the forest floor. ■

**Table 1. Buffer capacity on a unit area basis for a typical soil in Maine.**

Horizon	Thickness	Stone fraction	Organic fraction $\text{kg}_o \text{kg}_s^{-1}$	Bulk density $\text{kg}_s \text{L}_s^{-1}$	Buffer capacity	
					$\text{meq kg}_s^{-1} \text{pH}^{-1}$	$\text{kwq ha}^{-1} \text{pH}^{-1}$
	cm					
O <sub>e</sub>	5	0.00	0.93	0.11	93	5
O <sub>a</sub>	9	.00	.85	.12	85	9
E	8	.20	.02	1.40	4	4
B <sub>hs</sub>	6	.20	.13	.56	13	3
B <sub>s</sub>	22	.30	.08	.73	9	10
Total	50					31

## Literature Cited

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